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RESEARCH NOTE

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MEASURING SUBSURFACE STORMFLOW FROM SIMULATED RAINSTORMS--A PLOT TECHNIQUE

Difficulty in measuring subsurface stormflow rates and quantities has limited our understanding of stormflow processes in the Allegheny-Cumberland Plateau region. To overcome this obstacle we developed a system for collecting flow from the various layers in a soil profile during and after controlled, artificial "rains." The system involves a series of troughs installed in a pit so that water seeping out of various soil layers can be collected and measured. Directions for constructing such a system are given here.

Constructing the Subsoil Water Collection System

1. Dig a pit at the foot of the plot in which the subsurface stormflow is to be studied. (Our pits were dug about 2 feet deeper than the depth of the major fine-textured, water-flow-impeding layer. The pits were dug 15 feet wide, at a right angle to the general slope of the soil.)

2. Cut steps into the uphill face of the pit (fig. 1). Step treads need only be about 3 inches wide. Steps should coincide with soil horizons you want to sample flow from.

3. Plaster the sidewalls of the step system and the step tread tops with water-resistant mortar about 3/8 inch thick (figs. 1 and 2). This helps reduce inflow of foreign water and provides a solid material with which to anchor the water collectors.

4. When the mortar cement has dried, secure a sheet of heavy polyethylene plastic to the bottom step and to the sidewalls using asphalt cement (figs. 2 and 3). Cut the sheet wide enough to allow about 16 inches excess length at each end and long enough to reach the trough in step 5.

FIGURE 1.--Steps cut into the downslope soil face. Note the end walls and step treads are coated with a layer of mortar cement about 3/8 inch thick.

FIGURE 2.--Plastic sheet cemented to the step tread and sidewall and gathered into the trough. This provides a leakproof system that assures water draining into the trough.

FIGURE 3.--Bottom step fitted with plastic apron gathered into trough and filled with pea-sized gravel. As the trough is filled, boards are built up to contain the system in a gravel-filled box.

5. Gather the plastic material into a trough--this trough (equipped with an outflow pipe) should be about the same length as the steps. The seepage flow from the soil face trickles over this plastic "apron" into the trough and then into a diversion ditch. Samples are taken from this point.

6. Build a 3-sided box around the trough and plastic, and fill the box with pea-sized gravel (figs. 2 and 3). Then install the next highest trough, fitted with a plastic "apron," and enclose the entire system with a wooden box and fill with pea-sized gravel. Repeat this process for each of the remaining steps.

7. Finally, support the open soil on either side of the boxed-in collection system with 1/4-inch-mesh hardware cloth. Fill the small open space between the soil face and this screen with pea-sized gravel (fig. 4). Wet the gravel particles in contact with the soil face before "rain" begins in order to reduce surface tension and thus allow more natural outflow. The gravel also supports the troughs and braces against the soil face to minimize sloughing and erosion during extremely wet periods or intense storms.

FIGURE 4.--Open soil on both sides of the box collection system is screened and filled with gravel to prevent the soil from eroding and sloughing. This photo shows also the extreme-right end of the completely boxed-in, trough collection system. Note the height of wetting as shown by the darkened portion of the gravel.

The Rainmaker System

To make "rain" of controlled depths and intensities we used a plastic pipe system equipped with square-jet nozzles (fig. 5). We found that a Pacific-Marine, high-pressure pump provides the adequate, steady water pressure necessary to maintain the range of intensities required on the plot area. We produced rain intensities of 0.6 to 3.5 inches per hour by adjusting gauge pressure at the pump or manifold, or by varying nozzle sizes.

Rainfall was measured by collecting water in wooden troughs of prescribed dimensions (fig. 5) that drained into jugs.

Measurements of seepage resulting from a simulated storm can either be made with a flow-meter recording system or with timed, volumetric samples (fig. 6). The latter method is acceptable if most of the subsurface stormflow occurs during or several hours following the storm. For extremely large plots with much outflow, the recorder system is preferable.

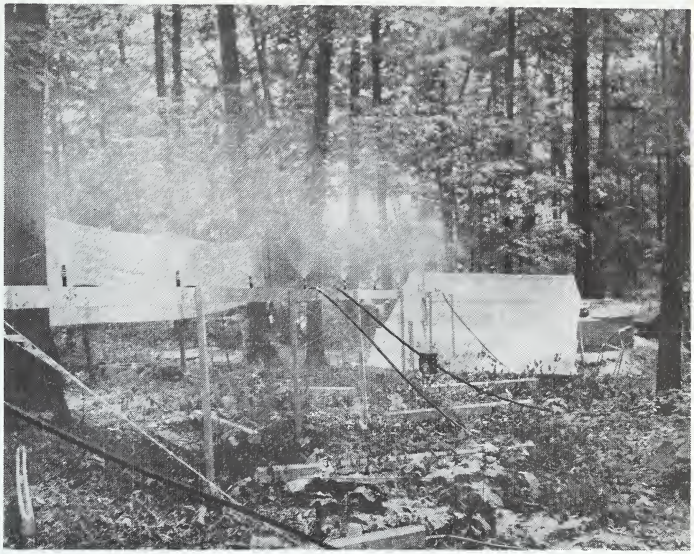

FIGURE 5.--Nozzles spraying water on a subsurface stormflow plot. The long, thin troughs placed diagonally in the plot provide a measure of the simulated rainfall. The multiple-unit tensiometers inserted in the soil measure hydraulic head before, during, and after the sprinkling operation.

FIGURE 6.--A portion of completed box containing the collection system. Note also technician collecting timed sample of outflow from a trough.

We do not recommend the use of artificial plot boundaries because they can lead to unnatural flow. In our first experiments we excavated all the way around the plot and covered the open faces with plastic. After a few "rains," flow began channeling along the plastic-soil interface.

We feel that by simply wetting 3 to 5 feet beyond the lateral plot boundary, water loss from the plot to the surrounding dry soil is eliminated.

The gradient of flow or potential flow in both saturated and unsaturated phases can be determined with tensiometers. Of the instruments commercially available for measuring soil water content or soil moisture tension in place, we prefer the multiple-unit tensiometer. This instrument has ceramic discs which can be spaced at various depths on a single stem depending on the local soil profile. This instrument not only gives a sensitive measure of tensions less than 850 centimeters but also indicates positive pressures, which is an advantage in plots where the soil is saturated part of the time. The tensiometer also indicates water flow direction, something other instruments used in measuring soil moisture content in heterogeneous, layered soils cannot do.

We have used this system for 4 years. It allows us to control amounts and rates of applied rainfall and gives a quantitative picture of soil-water buildup within the plot and seepage outflow from the plot. Thus, we can now study an important component of the interconnected hydrologic cycle--one that has been poorly understood.

With this system, which has been used successfully for more than 100 separate storms, we now can study the effect soil types and textural differences within the soil types have on converting rainfall into stormflow. We find, too, that this system when carefully constructed is tight enough and reliable enough to reproduce results from independent but similar intensity-duration storms.

This research is being conducted in cooperation with the Muskingum Watershed Conservancy District. For further information on materials, equipment, or techniques involved we invite interested readers to write us.

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